THE METROLOGY OF SPHERICAL SHELLS USING SYNCHROTRON X-RAY MICROTOMOGRAPHY

Anthony B. Hmelo and James L. Allen
Vanderbilt University

Kevin L. D'Amico
EXXON Research and Engineering Company

Sandia National Laboratories has a need for large, high quality spherical shells for its Inertial Confinement Fusion project . The Jet Propulsion Laboratory has developed the technique to produce these spherical shells and Vanderbilt University is continuing to refine the process for producing larger, higher quality shells. In order to assess the usefulness of the product shells, it is necessary to characterize them using a non-destructive technique.

With recent advances in solid state imaging technology, and the increasing availability of synchrotron x-ray radiation sources, synchrotron x-ray microtomography is emerging as a nondestructive technique for the evaluation of the structure and composition of small specimens with spatial resolution in the micron range. Synchrotron radiation offers the following advantages over conventional x-ray sources: 1) high brightness; 2) continuous emission which is tunable over a large energy range; 3) faster data collection rates; 4) highly collimated beam of large cross-section permitting the illumination of large specimens. Synchrotron x-ray microtomography enables the structure of individual spheres to be evaluated in order to reveal the concentricity and sphericity of the internal void and the uniformity of the shell wall.

The Center for Microgravity Research and Applications has been utilizing the unique capabilities of the EXXON X-2 X-ray beamline at National Synchrotron Light Source (NSLS) to evaluate the application of microtomography to characterize spherical shells. Currently the work is performed on a collaborative basis with EXXON. This work will be illustrated with reconstructions of some of the recent shell product.

Materials characterization techniques are used to document the effect of processing materials in a microgravity environment. Generally, these specimens are so valuable that one wants to obtain as much information as possible from as few as a single specimen that may be returned from space. Preferably we want to use techniques which preserve the specimen for subsequent analysis.

Microtomography provides a nondestructive means to map the x-ray attenuation coefficient of a specimen in three dimensions. Local variations in the mass attenuation coefficient may be due to changes in density or composition within the specimen. These variations are interpretable in terms of the microstructure.

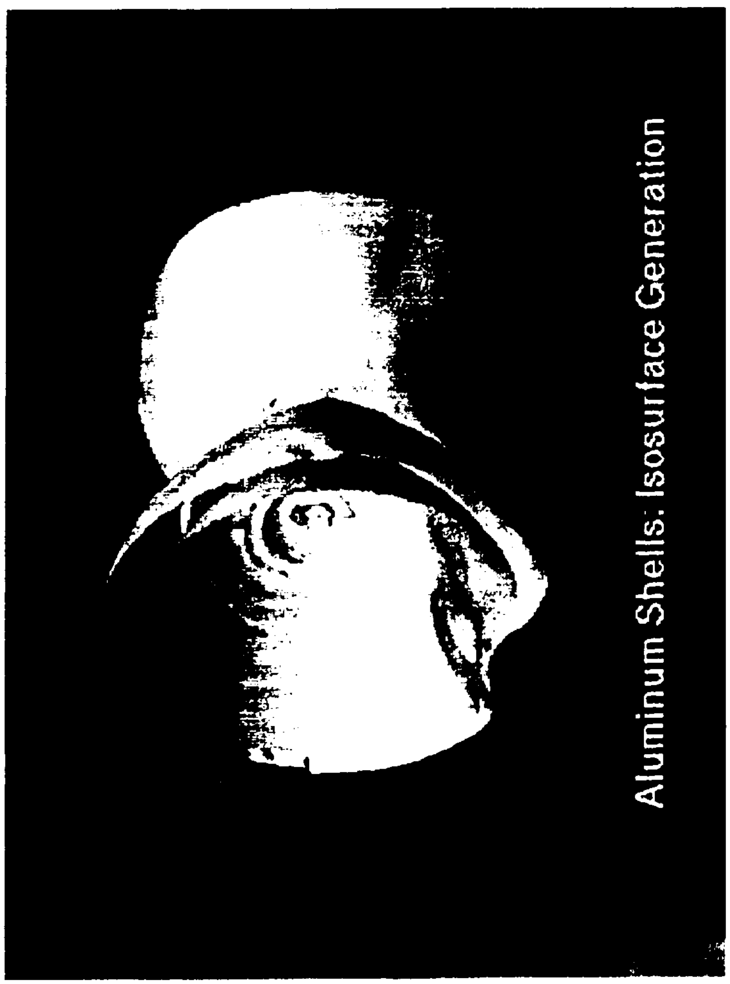
This paper presents the results of a nondestructive evaluation of the structure of aluminum spherical shells using synchrotron x-ray microtomography. These structures were solidified from the molten state under microgravity conditions in the JPL cryogenic drop tube facility. We are specifically interested in obtaining information on the structure of the internal void, and the uniformity of the shell wall thickness.

In the figure we show a reconstruction of two shells which have collided during the free fall in the drop tube before they were completely solidified. We have presented the data in terms of an isosurface generation, marking the transition in attenuation at the outer surface of the sphere and the inner surface of the shell wall where the density changes from gas to aluminum.

The shells are 2mm in diameter with a 200 micron wall thickness. The point resolution in this data set is 6 microns. Each shell has been mathematically "sectioned" to reveal the interior surface of the void. Despite the irregular shape of some of the shells, it is noteworthy that the voids themselves are so spherical.

There is a need for 'on-orbit' characterization capabilities aboard space station. Though it is impractical to propose a tomography facility, at a minimum, a simple radiography system would be very useful for documenting the 'as-grown' condition of some fragile materials which may be damaged by decelerations upon their return to earth, or simply as a diagnostic tool for monitoring various solidification experiments.

Strategic planners should note that several presentations at this workshop have been devoted to the need for materials characterization.



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GARY HILL